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DATA QUALITY ASSURANCE FOR RIBS XM2000

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Abstract

The U.S. Army Engineer Research and Development Center (ERDC) performed the Rapidly Installed Breakwater System (RIBS) XM2000 Experiment in June-July 2000 at the Naval Air Station (NAS), Pensacola, Florida. An extensive instrumentation was installed on the RIBS in order to measure wind, waves, RIBS motion, and mooring line loads. During the experiment, a first-level data analysis and data quality checking for collected data was executed in order to allow a reliable second-level analysis and additional post-processing.

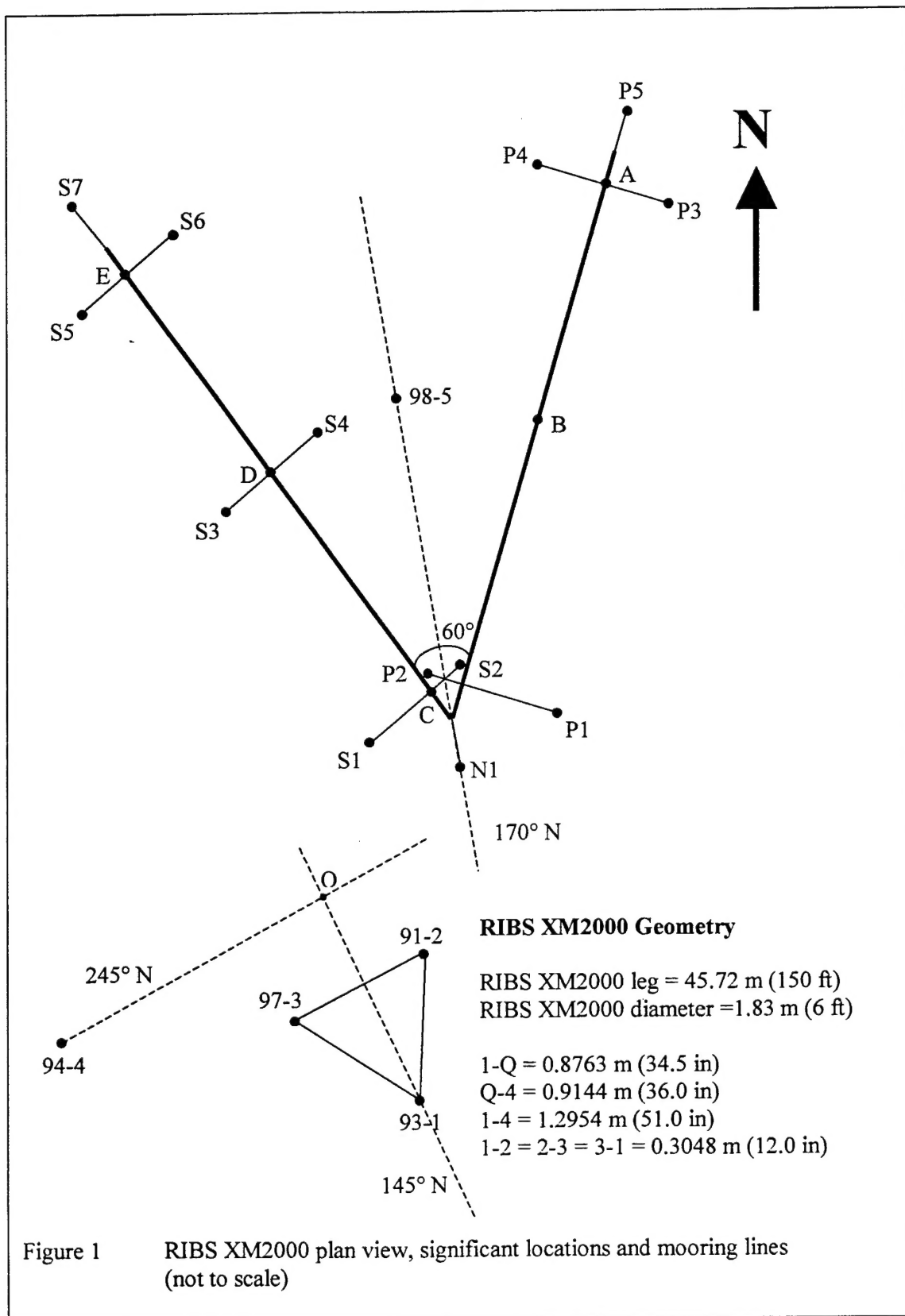
1. Introduction

The Rapidly Installed Breakwater System (RIBS) is being developed at the U.S. Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL) to mitigate the impact of elevated sea states when equipment and supplies are being projected in support of military offloading ship operations during Logistic Over The Shore (LOTS). In these operations, supplies from sealift ships are offloaded at offshore anchorages onto smaller vessels termed lighters. Lighters then transport the supplies to smaller ports and harbors, to causeways along the shore, or directly onto the beach. Past exercises and operations have shown that the capability to conduct LOTS operations is presently limited to Sea State 1 and 2, or significant wave heights up to 0.91 m (3 ft). Sea State 3 (SS3) conditions consist of waves with peak periods in the range 3 to 6 sec and significant wave heights between 0.91 m to 1.52 m (3 to 5 ft) (Fowler et al. 1997).

The RIBS is a floating breakwater with two legs in a "V" shape in plan view, that provide a sheltered region from waves and currents (Briggs 2000). Figure 1 shows a plan view of the RIBS XM2000 along with its significant locations where instruments were installed, and mooring lines (not to scale). This system can reduce wave heights for periods less than 6 sec by 50% or more in its lee, in order to enable LOTS operations to continue through SS3. Due to the angle that the legs make to the incoming waves, the RIBS concept is based on the capability of its legs to diffract and reflect incoming waves (Resio et al. 1997).

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Laboratory and field experiments have been planned and executed by CHL since the beginning of the RIBS program in 1995. The RIBS XM2000 is the latest field experiment conducted in June-July 2000 at the Naval Air Station (NAS), Pensacola, Florida.

2. RIBS XM2000 Field Experiment

The RIBS XM2000 was deployed in Pensacola Bay, Florida, on June 2000. This version had a 1/4 model to prototype scale, and consisted of two cylindrical legs which were made from a marine textile material and filled with water. Each leg was 45.72 m (150 ft) long, with a diameter of 1.83 m (6 ft), and consisted of two segments of length of 22.86 m (75 ft). Water depth during the performance phase was 3.66 m (12 ft).

2.1 Instrumentation

The RIBS XM2000 instrumentation included sensors for measuring wind, incident and transmitted waves, structural motions and mooring line loads. Data were collected by "master slave" data loggers located longitudinally at the bow, middle and stern of each leg. A self-contained, omni-directional Datasonics Acoustic Telemetry Modem transferred data to a shore-based data acquisition and analysis system, located in the Instrumentation Trailer. These data for the entire system were monitored, collected, analyzed, stored and recorded on CD-ROM's during the experiment.

2.1.1 Anemometer

An anemometer recorded wind speed (m/s), direction (deg), and bearing (deg). Originally, it was located at the end of pier of the NAS, but later was moved to the XM2000 to record actual winds on the model structure.

2.1.2 Accelerometers

Tri-axial accelerometers were installed to measure vertical, lateral, and surge accelerations. Accelerometers record A_x , A_y , and A_z in units of g's. To get accelerations of m/sec^2 , multiply by 9.806 ($1 \text{ g} = 9.806 \text{ m/sec}^2$). Acceleration ranges between $\pm 2 \text{ g's}$ were recorded. According to the right hand rule, accelerometer orientation is as follows: positive x axis points to stern, positive y axis points to starboard, positive z axis points up. When facing the bow, gage code can be read from left to right. Displacements were obtained via integration of accelerations.

2.1.3 GPS sensors

Global Positioning System (GPS) loggers were located on each leg to monitor RIBS motion. The GPS sensors measure latitude, longitude, and elevation in units of meters. These integrated GPS receivers were capable of sub-meter positioning accuracy and provided superior weak-signal reception, allowing differential corrections over long

distances and challenging weather conditions. Maximum GPS readings at the performance site (water depth of 3.66 m or 12 ft) should be less than 1200 m, and less than 300 m at the survival site (water depth 6.01 m or 20 ft).

2.1.4 Load cells

Mooring line loads were measured with load cells. Tables 1 and Figure 1 show the sequencing of load cells with mooring line, location, instrument POD, and serial number. The units of load in the load cells are volts, and each has a specific calibration. The linear fit includes intercept (set to 0) and slope coefficients. Load cells had a maximum range of 10,000 lb. and a resolution of approximately 2 lb.

Table1				
List of Load Cell Parameters				
ID #	Location on RIBS	Instrument POD	Serial Number	Mooring Line
1	A	0507	69529	P5
2	C	0524	69524	P1
3	C	0524	69525	N1
4	C	0524		S2 (Absent initially)
5	C	0524		P2 (Absent initially)
6	D	0511	69527	S3
7	D	0511	69526	S1
8	D	0511		S4 (Absent initially)
9	E	0526	69528	S5
10	E	0526	69530	S7
11	E	0526		S6 (Absent initially)

2.1.5 Incident and transmitted wave gages

Five Ocean Systems capacitance wave gages were used to measure incident and transmitted wave heights. The wave staffs were 3 m long, centered in the water column (i.e., 1.5 m in and out of the water), and attached to a pile. An equilateral triangular array, each side of 0.3048 m (1 ft), along with a single wave gage were installed in front of the RIBS to measure incident wave heights. Transmitted wave heights were measured with a single wave gage, located in lee of the nose along the centerline. Figure 1 shows a plan view of the gages along with the RIBS. The four incident wave gages were contained in four channels using the same instrument POD or canister, with units of volts. The calibration factor is 0.51 volts/ft or 1.96 ft/volt. The same calibration factor is applied to the wave gage for transmitted waves.

2.1.6 Instrumentation summary and sampling rates

In total there were: 7 accelerometers, 5 GPS, 11 load cells, 4 gages for incident waves (an equilateral triangular array, each side of 30.48 cm (1 ft), and 1 single gage), 1 gage for transmitted waves (along the centerline in the sheltered area of the RIBS), and 1 anemometer. Initially, there are only 7 load cells: P5, P1, N1, S3, S1, S5 and S7. Load cells added later include the interior locations P2, S2, S4 and S6.

All instrumentation is sampled for 30 minutes at 4 Hz, except for the anemometer and the GPS. The anemometer is sampled at 1 Hz. The GPS is also sampled at 1 Hz, but stored at 4 Hz. This means that every consecutive 4 points are the same, so the user should select every 4th point (i.e.: 3,3,3,3,7,7,7,7,15,15,15,15...).

3. Data collection and organization

All collected data from the experiment were recorded in a CD-ROM. The data are in ASCII format, there were no computed statistics on the disc and the units were not modified. The data were grouped according to the day collected and further grouped by type as given in the table below. All data were archived using WINZIP32.

All data collection occurred during the first half of each hour, with data transmission during the second half. Clock was set for Central Standard Time (CTS), there was no Daylight Saving Time (DST).

In each ZIP file, the file names were in the form 1700520m.019. This naming convention gave the Julian Day as the first three digits: 170 corresponded to 18 June 2000, 171 corresponded to 19 June 2000, and so on. The next four digits gave the serial number of the data acquisition POD. For the file name above, the POD was 0520, or just 520. The next letter in the file name gave the file type. The original files were named 'b' files. All files were subsequently post-processed and renamed 'm' files for compatibility with GEDAP™. The file extension was the time of day in hours that the data were written (i.e. 019).

The RIBS XM2000 ZIP data files are shown in Table 2 corresponding to the location on the RIBS, the POD and the data type. Each 'm' file contained the header records from the original 'b' file except that there was an asterisk (*) inserted at the beginning of each line to facilitate easier reading for GEDAP™. All data were demultiplexed so that one column corresponded to one channel.

Data collection started on JD 174 (22 June 2000) at hour 000, except for wave data. Wave data collection (POD 0520 and 0522) started on JD 180 (28 June 2000) at hour 012 (wave gages were sampled for 30 minutes at 4 Hz). From JD 182 (30 June 2000) at hour 010 to JD 188 (6 July 2000) at hour 010, wave gages (POD 0520 and 0522) were sampled at 10 Hz. From JD 188 at hour 011, wave gages sampling was set back to 4 Hz.

Table2**RIBS XM2000 data files**

ZIP File	Data Type	Units	POD	Location on RIBS	Channels
A_0507_0515_mfiles	Acceleration	G	0507	A, Starboard side of port leg	6: A _x , A _y , A _z , L(P5), J, J
	Loads	volts			
B_0516_mfiles	Acceleration	G	0515	A, Port side of port leg	6: A _x , A _y , A _z , Lat, Long, Elev
	GPS	m			
C_0517_0524_mfiles	Acceleration	G	0516	B, Port side of port leg	6: A _x , A _y , A _z , Lat, Long, Elev
	GPS	m			
D_0511_0518_mfiles	Acceleration	G	0517	C, Starboard side of starboard leg	6: A _x , A _y , A _z , Lat, Long, Elev
	GPS	m			
E_0519_0526_mfiles	Loads	Volts	0524	C, Port side of starboard leg	4: L(P1), L(N1), L(S2), L(P2)
D_0511_0518_mfiles	Acceleration	G	0511	D, Port side of starboard leg	6: A _x , A _y , A _z , L(S3), L(S1), L(S4)
	Loads	volts			
E_0519_0526_mfiles	Acceleration	G	0518	D, Starboard side of starboard leg	6: A _x , A _y , A _z , Lat, Long, Elev
	GPS	m			
E_0519_0526_mfiles	Acceleration	G	0519	E, Starboard side of starboard leg	6: A _x , A _y , A _z , Lat, Long, Elev
	GPS	m			
IW_0520_mfiles	Loads	Volts	0526	E, Port side of starboard leg	4: L(S5), L(S7), L(S6), J
IW_0520_mfiles	Incident Waves	Volts	0520	In front of the nose	4: 93(1), 91(2), 97(3), 94(4)
TW_0522_mfiles	Transmitted Waves	Volts	0522	In lee of the nose on center line	1: 98(5)
An_0501_mfiles	Anemometer	m/sec degrees degrees	0501	End of pier	3: Speed, Direction, Bearing

Note: J is a symbol for recorded data that were bad and considered as "junk" that do not need to be processed.

4. Data analysis

A first-level data analysis and data quality checking for collected data was performed using GEDAP™ analysis package, hereafter referred to as GEDAP. GEDAP is a general purpose software package for the analysis and management of laboratory data including real-time experiment control and data acquisition functions, time and frequency domain analysis, and data manipulation and presentation. GEDAP is developed by the NRC (National Research Council Canada) Canadian Hydraulics Centre (<http://www.chc.nrc.ca>).

GEDAP was used to analyze time series of pertinent parameter as incident and transmitted wave heights, wave periods, transmission coefficients, GPS displacements (Latitude, Longitude and Elevation), accelerations, displacements (via integration of accelerations), and anchor line loads. GEDAP scripts for RIBS XM2000 data analysis were created by editing previous GEDAP scripts used for second-level data analysis and additional post-processing for RIBS XM99 Experiment (Cape Canaveral, Florida, May 1999), performed by the Authors of this report.

A Matlab™ version of the Maximum Likelihood Method (MLM) directional spectral analysis was also used. Data analysis for RIBS XM2000 was performed following the guidelines reported in Briggs (2000), but using appropriate values for Nyquist frequency and limit frequencies on the filter applied to the time series.

Each day of the experiment, the 24-hour data retrieved from the instrumentation through the telemetry system concerning the previous day were reported in a journal. In this way it was possible to check the telemetry system by calculating the percentage of data retrieved hourly that day for each instrument, and know the data available for that day to be analyzed. Data analysis allowed to know in real-time all pertinent parameters, and perform an effective checking of the instrumentation, in order to organize immediate operations for repair of the instrumentation by the CHL Personnel, if needed.

Figures A.1 through A.10 in Appendix show GEDAP and Matlab™ outputs for RIBS XM2000 data analysis. Data quality checking and data analysis performed during the experiment allow CHL personnel and other Researchers/Scientists to perform a reliable second-level analysis and additional post-processing.

5. Summary and Conclusions

The U.S. Army Engineer Research and Development Center (ERDC) performed the RIBS XM2000 Experiment in June-July 2000 at the Naval Air Station (NAS), Pensacola, Florida. An extensive instrumentation program was planned in order to measure all pertinent parameter as incident and transmitted wave heights, wave periods, transmission coefficients, GPS displacements (Latitude, Longitude and Elevation), accelerations, displacements (via integration of accelerations), and mooring line loads. During the experiment, the features of each installed instrument, name, position and collected parameters were reported on a data-log book. The collected data were organized and recorded in a CD-ROM in order to allow CHL and other Users both quick access and easy understanding of data organization. A first-level data analysis and data quality checking for collected data was performed in order to ensure a reliable second-level analysis and additional post-processing. This initial effort gave to the CHL a first idea of the system performance and structure response. Collected data will be used for the final design of the prototype RIBS for use in the Advanced Technology Demonstration (ADT).

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Resio, D. T., Briggs, M. J., Fowler, J. E., and Markle, D. (1997). Floating V-shaped breakwater", U.S. Patent No. 5.702,203, December 30, 1997.

APPENDIX

Figures A.1 through A.10

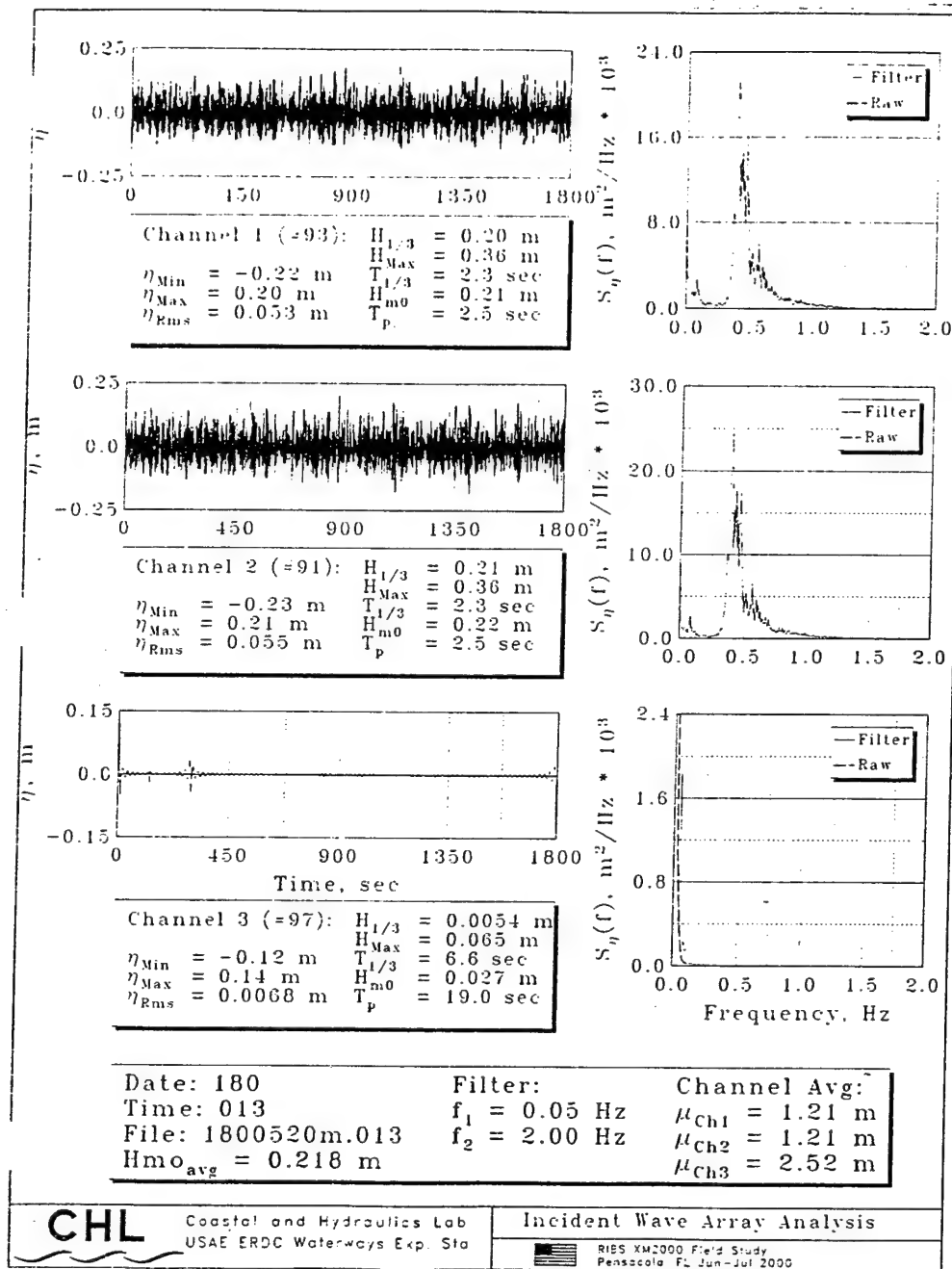


Figure A.1 GEDAP output for Incident Waves (NonDirectional Analysis)
Gages 93, 91, and 97 (gage 97 was not working) - Julian Day 180, hour 013

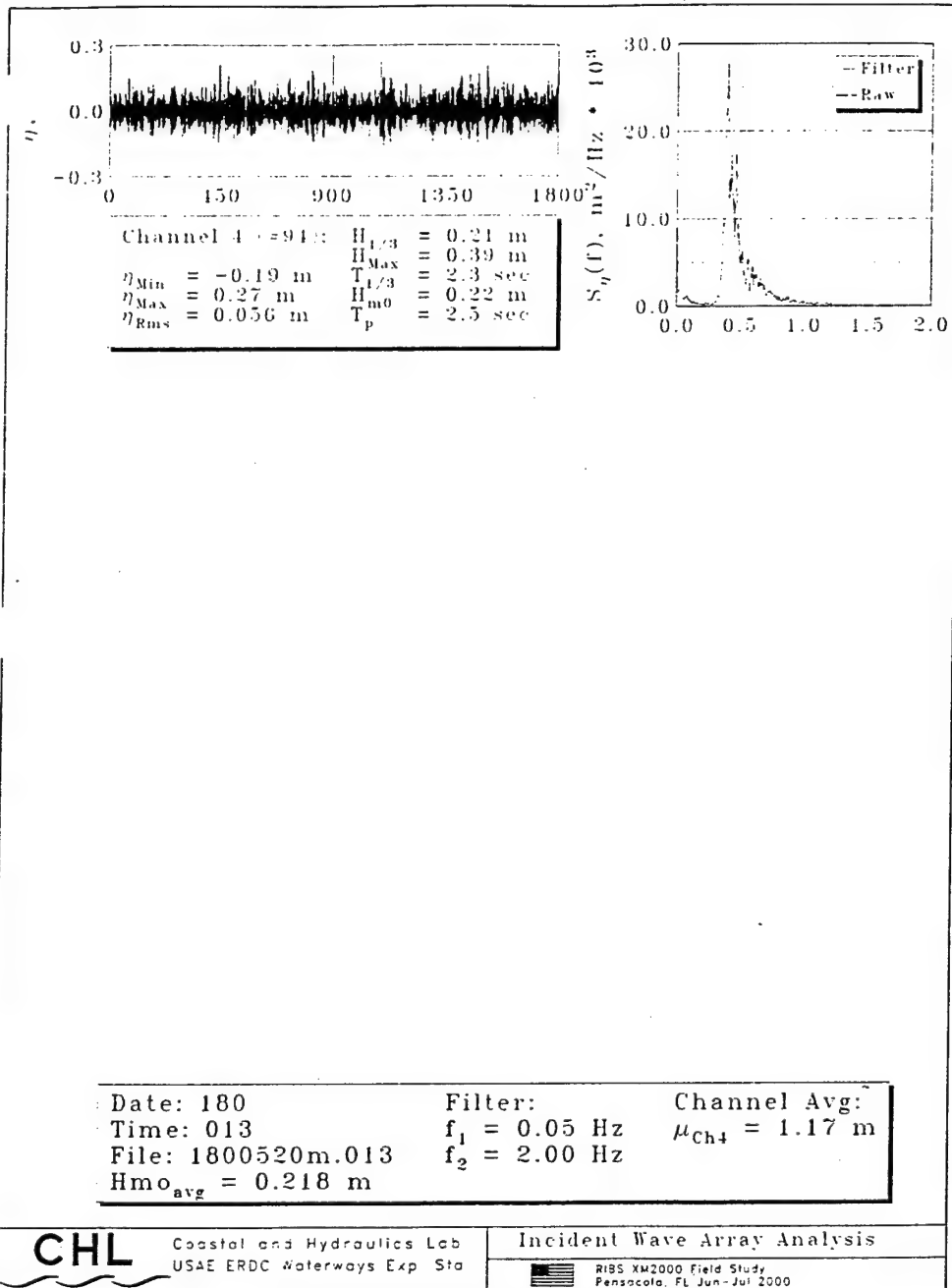


Figure A.2 GEDAP output for Incident Waves (NonDirectional Analysis)
Gage 94 - Julian Day 180, hour 013

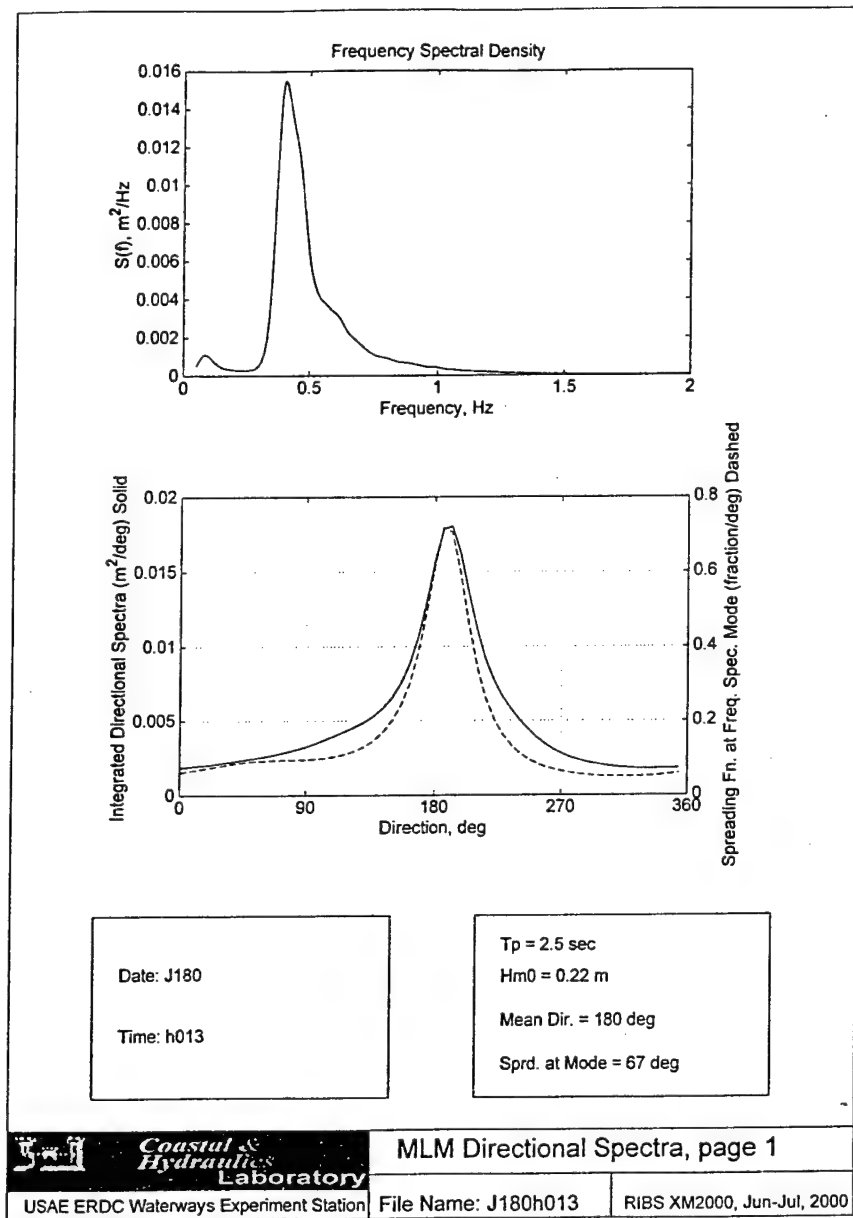


Figure A.3 Matlab™ output for Incident Waves - Julian Day 180, hour 013 (MLM Directional Analysis, page 1)

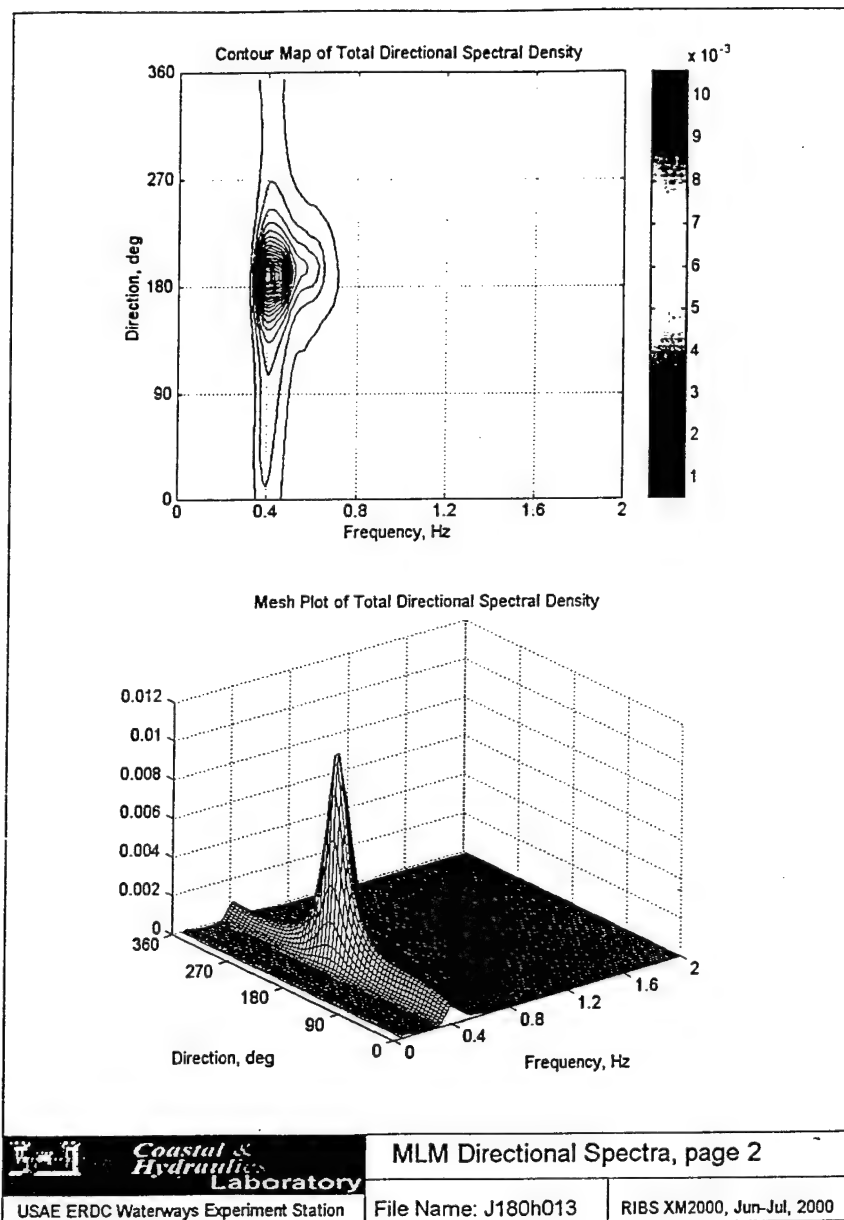


Figure A.4 Matlab™ output for Incident Waves - Julian Day 180, hour 013
(MLM Directional Analysis, page 2)

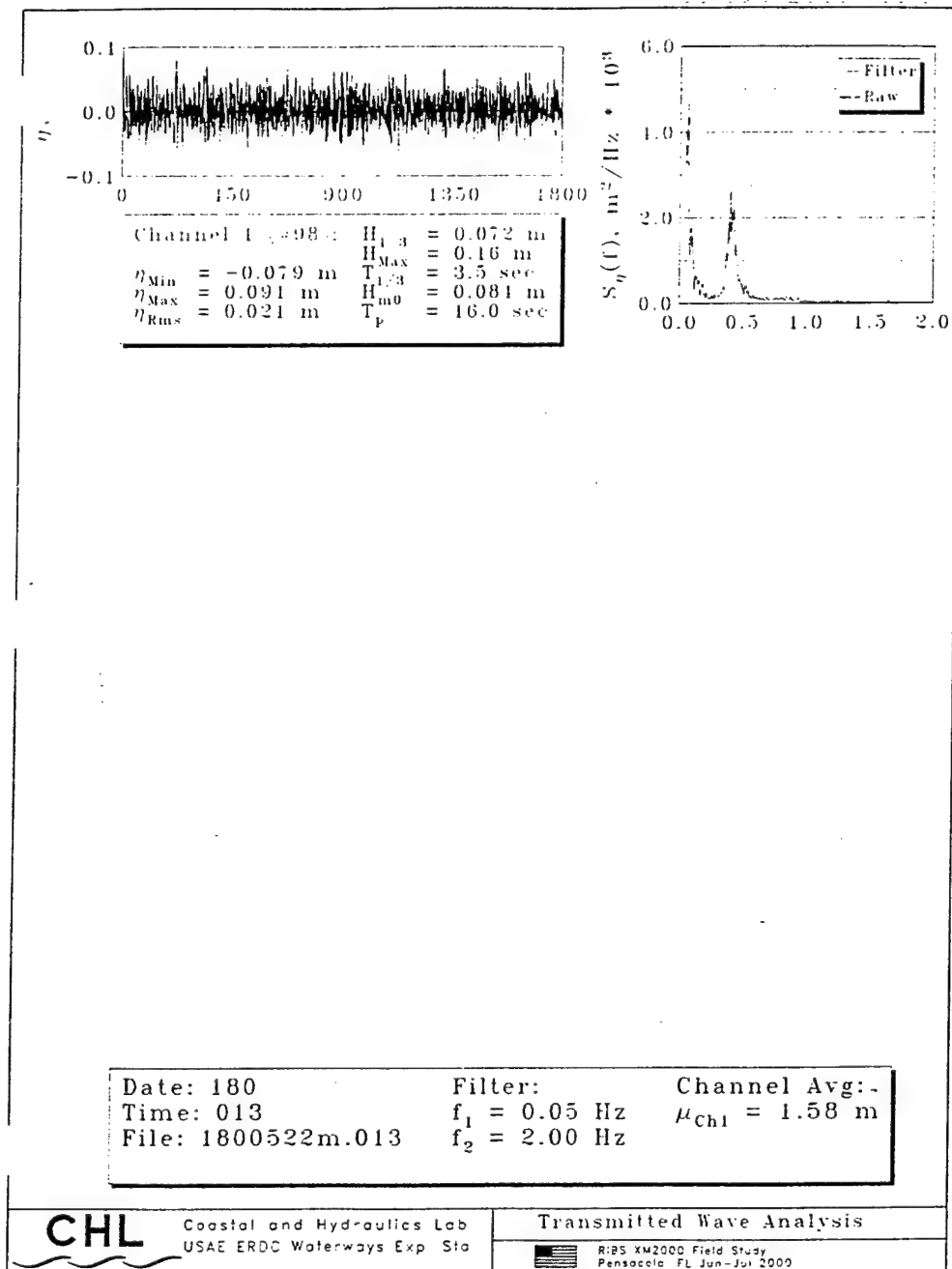


Figure A.5 GEDAP output for Transmitted Waves
Gage 98 - Julian Day 180, hour 013

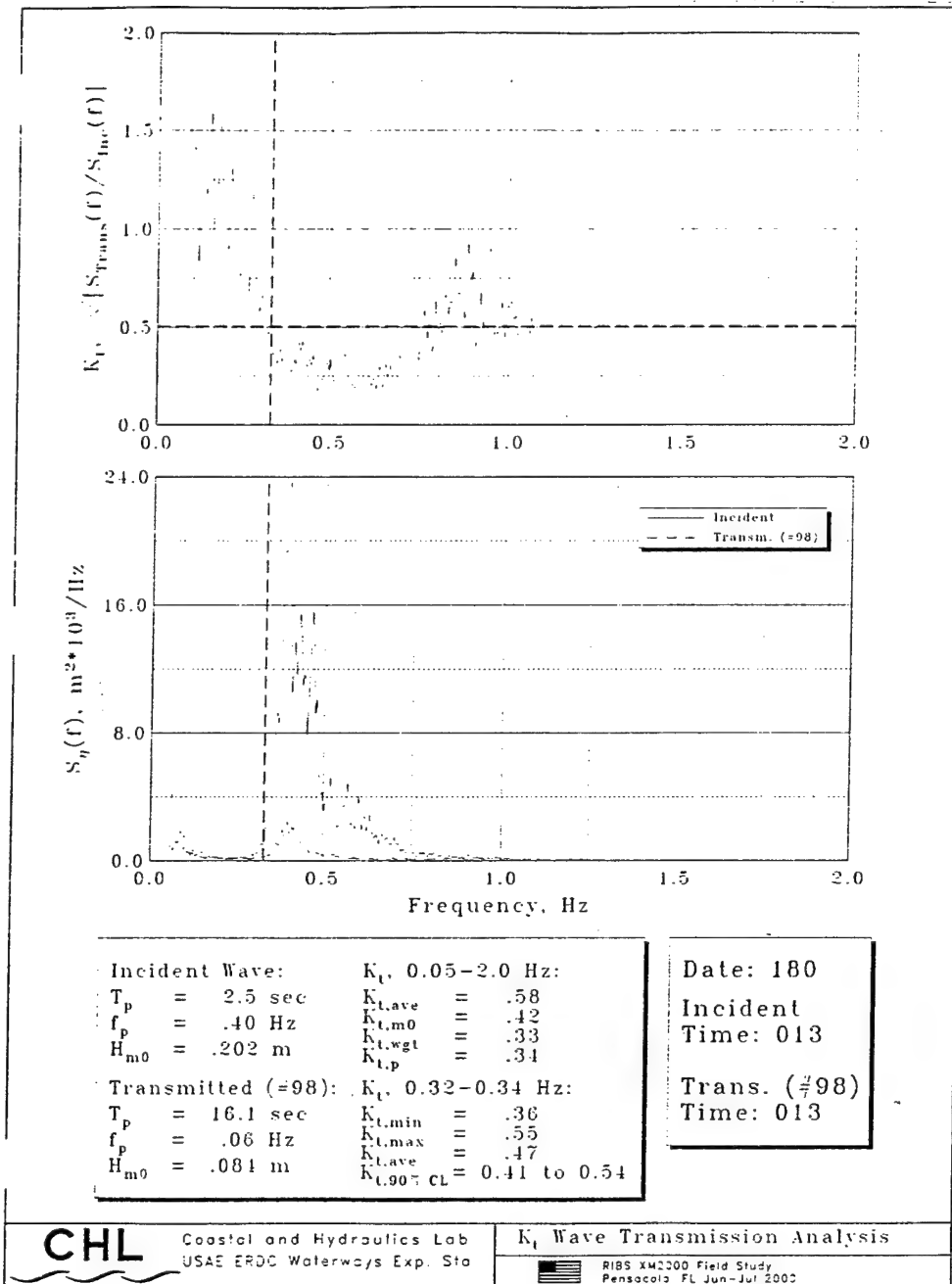


Figure A.6 GEDAP output for K_t Transmission Coefficient
Julian Day 180, hour 013

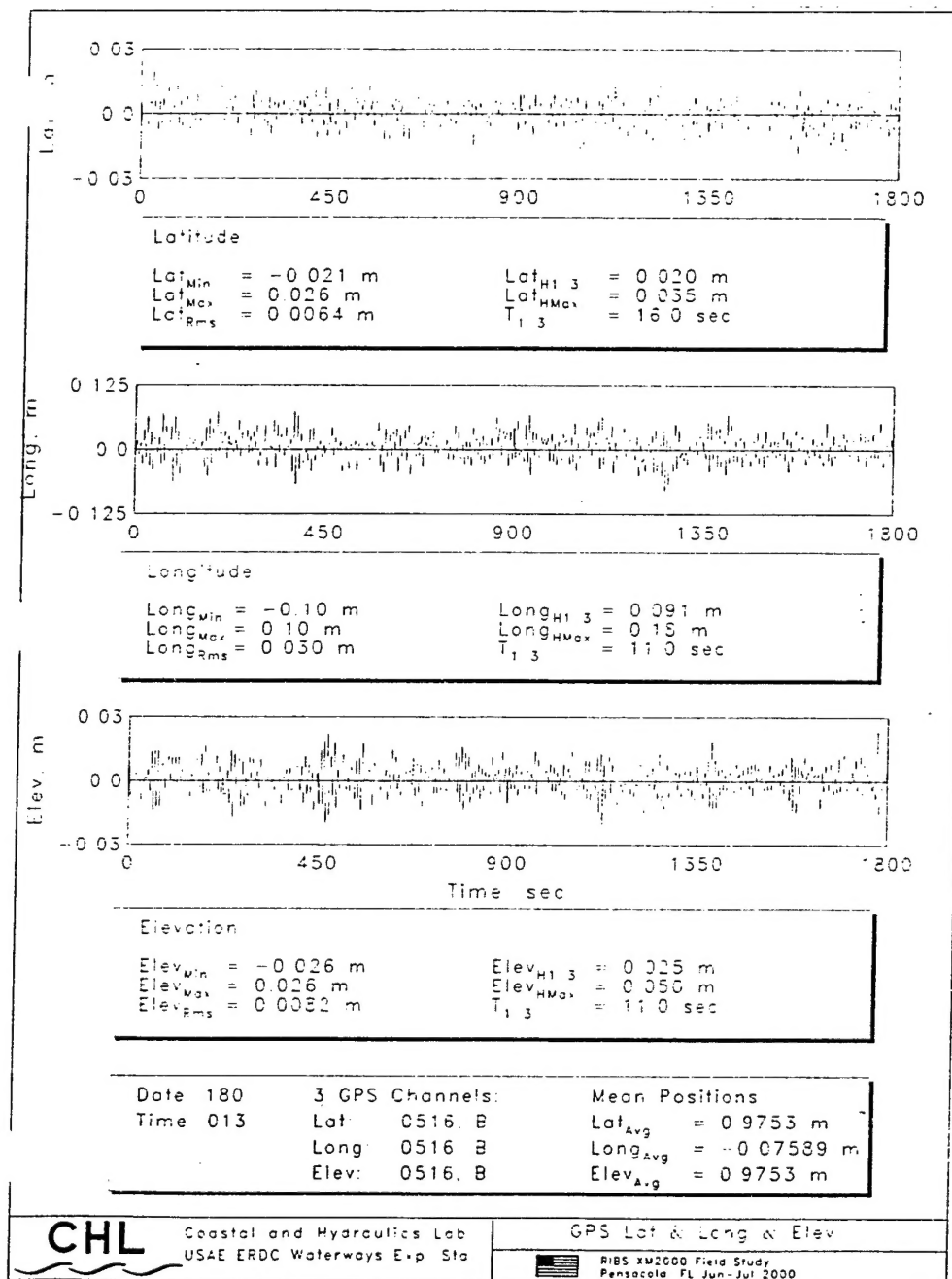


Figure A.7 GEDAP output for GPS (Latitude, Longitude and Elevation)
Julian Day 180, hour 013

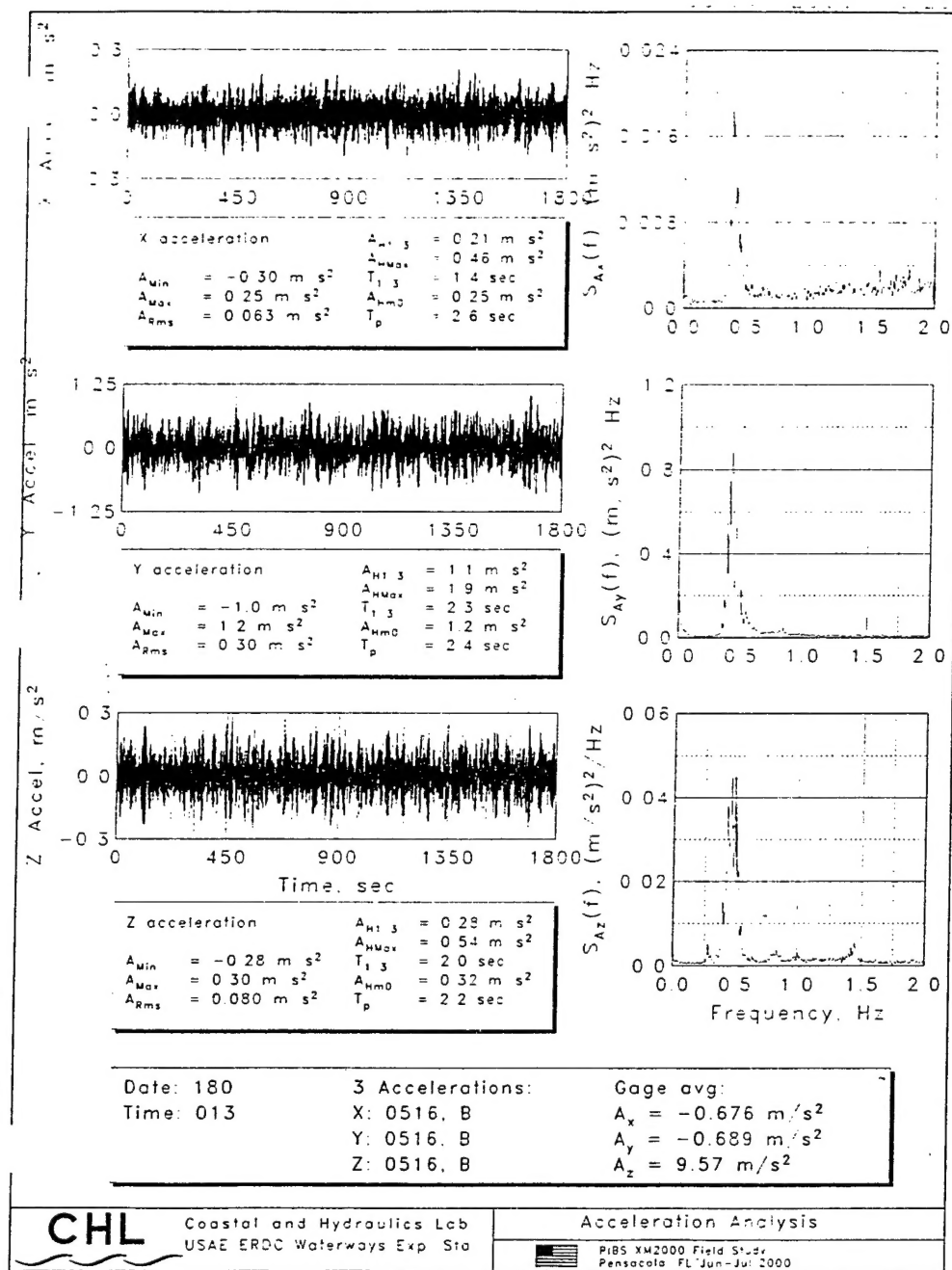


Figure A.8 GEDAP output for Accelerations - Julian Day 180, hour 013

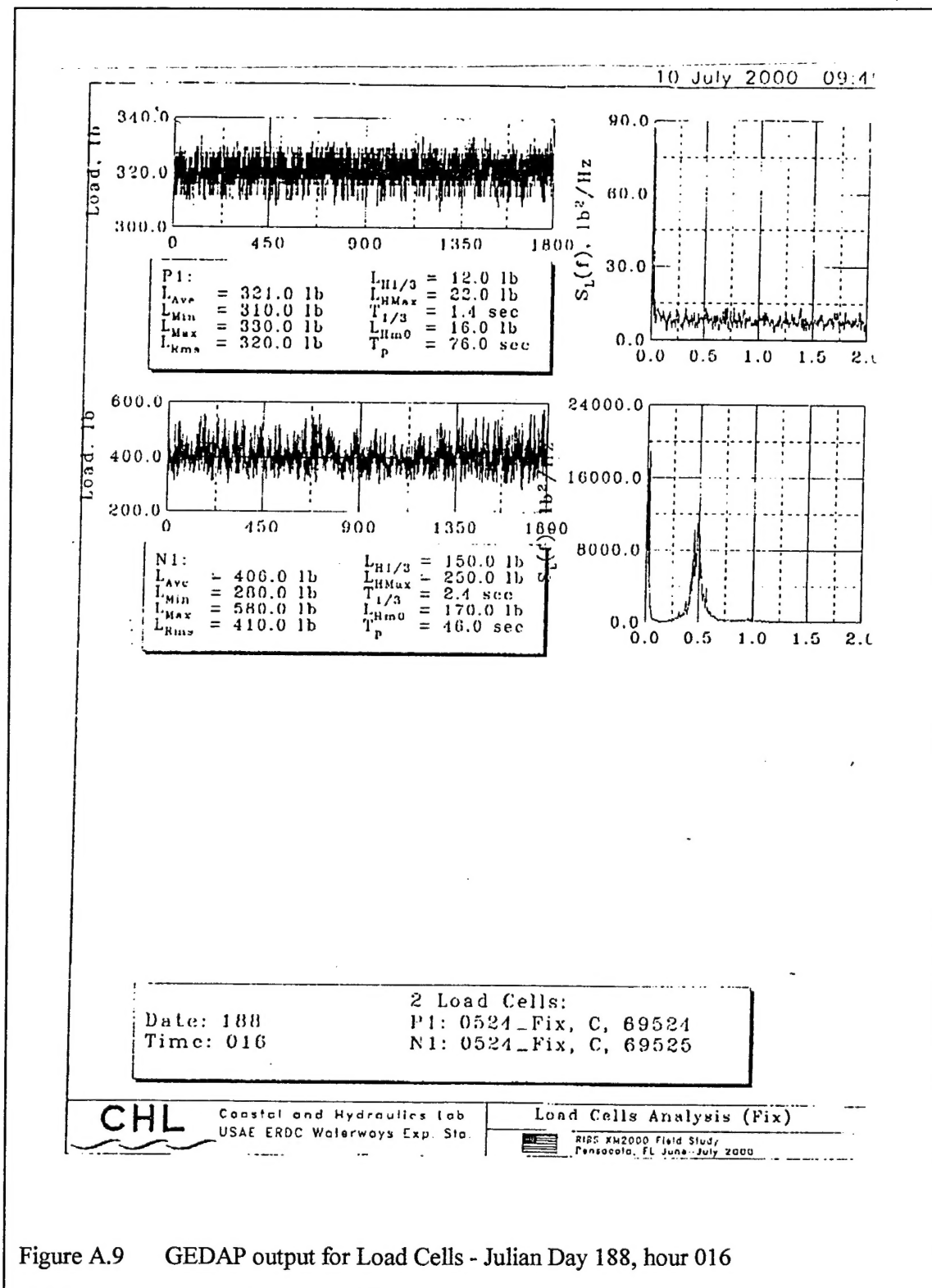


Figure A.9 GEDAP output for Load Cells - Julian Day 188, hour 016

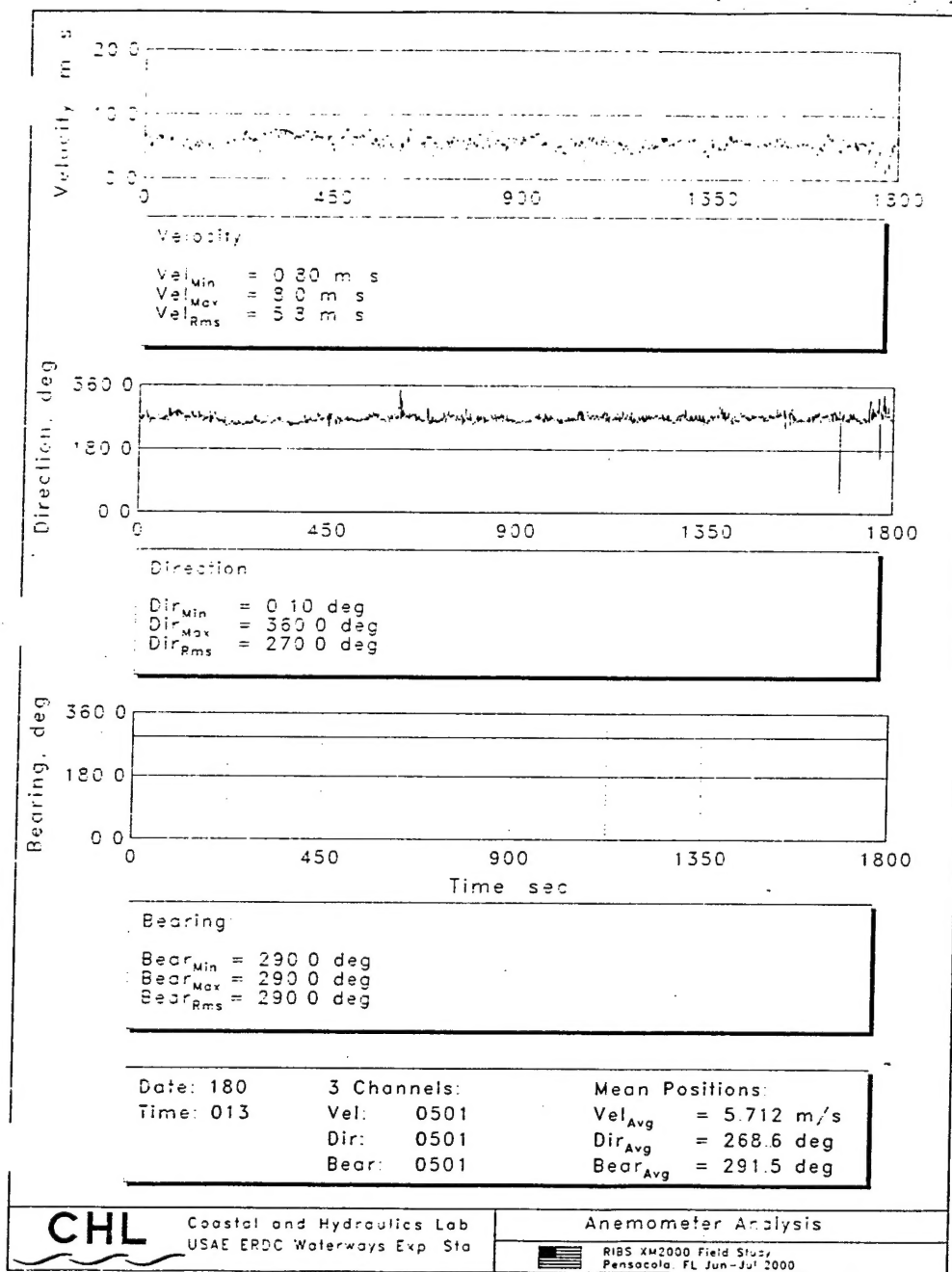


Figure A.10 GEDAP output for Anemometer - Julian Day 180, hour 013